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A comparison of the chemical composition and bioactive ingredients of the Chinese medicinal mushroom DongChongXiaCao, its counterfeit and mimic, and fermented mycelium of *Cordyceps sinensis*

Tai-Hao Hsu*, Li-Hua Shiao, Chienyan Hsieh, Der-Ming Chang

Department of Food Engineering, Da-Yeh University, 112 Shan-Jiau Rd., Da-Tsuen, Changhua, 515, Taiwan, ROC

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Abstract

The Chinese herbal drug DongChongXiaCao, a medicinal and edible mushroom originating from the fungus *Cordyceps* sp., has been developed into health foods. Counterfeit and mimic types are frequently found in markets. Mycelial preparations of *Cordyceps sinensis,* via submerged fermentation, have been commercialized and also named DongChongXiaCao. This investigation endeavours to characterize the proximate composition, amino acid profiles, and contents of the bioactive ingredients, including adenosine and cordycepin. The total levels of amino acids were significantly different, ranging from 4 to 17%. Glutamic acid and aspartic acid were the two main amino acids in all samples tested; however, there was a third major amino acid. The level of total amino acids in the mycelium was only half that in the natural DongChongXiaCao. The bioactive ingredients adenosine and cordycepin did not exist in the counterfeit and mimic types. Adenosine was abundant in the fruiting body, amounting to considerably more than in the corpus of the natural DongChongXiaCao and the mycelium of *C. sinensis*. Trace levels of cordycepin were found in all the *Cordyceps* preparations. These findings suggest that adenosine and cordycepin might be used as indexing ingredients for differentiating *Cordyceps* from the counterfeit and the mimic.

Keywords: DongChongXiaCao; *Cordyceps sinensis*; Counterfeit; Mimic; Fermented mycelium; *Stachys geobombycis*; Chemical composition; Adenosine; Cordycepin

1. Introduction

The caterpillar-shaped Chinese medicinal mushroom "Winter-Worm-Summer-Grass", called "DongChongXiaCao" in Chinese and "Tochukaso" in Japanese, is derived from the larva of *Hepialus armoricanus* infected by the entomopathogenic fungus *Cordyceps* sp., generally recognized as *Cordyceps sinensis*. In addition to its usage as a crude drug, it has been used extensively as a folk tonic food or invigorant by the Chinese. Because this herbal medicine is so scarce in nature and high in price, a counterfeit, possibly made from dough, and a mimic derived from the root of the *Starchys geobombycis* plant are frequently found in markets in Taiwan. Recently, extracts of DongChongXiaCao and fermented mycelia of *Cordyceps sinensis*, in capsule or tablet form, have been accepted as nutraceuticals or health foods, which are very popular in China and Japan.

The scientific re-discovery of the broad medicinal effects and utilization of the ancient Chinese herb in immunoregulatory, oxygen-free-radical-scavenger, antisenescent, endocrinological, hypolipidemic, hypoglycemic, antitumor, antiatherosclerotic and sexual-function-restorative activities, as well as in preclinical in vitro and in vivo usage, has been reviewed in the literature (Halpern, 1999; Kiho & Ukai, 1995; Mizuno, 1999; Zhu, Halpern, & Jones, 1998a,b). The early usage of medicinal mushrooms for health benefits was most probably in the form of extracts, concentrates, or powders now termed "mushroom nutraceuticals" or dietary supplements (Smith, Rowan, & Tan, 2000).

* Corresponding author. Tel.: +886-4-8511888x2288; fax: +886-4-8511304.

E-mail address: th4420@ms36.hinet.net (T.-H. Hsu).

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Edible mushrooms have multiple functional properties (Chang, 1996), and the chemical analysis of mushrooms not only provides information concerning nutritional value, but also differentiates the species and strains having morphological similarity (Senatore, 1992). Adenosine and cordycepin, in *Cordyceps*-related species, have usually been assumed to be bioactive ingredients (Hsu, 1999). Adenosine has a number of actions that merit it as a possible cardioprotective and therapeutic agent for chronic heart failure (CHF; Kitakaze & Hori, 2000). Adenosine is also a local hormone with numerous tissue-specific biological functions. In the myocardium, adenosine is released in small amounts at a constant basal rate during normoxia, and the effects of such interventions have been observed during ischaemia and reperfusion (Sommerschild & Kirkeboen, 2000). Cordycepin (3′-deoxyadenosine, 3′-dA) is a nucleoside analogue, which exhibits antileukemic activity against terminal deoxynucleotidyl transferase-positive (TdT+) leukemic cells and has been considered as a therapeutic agent for TdT+ leukemia (Kodama, McCaffrey, Yusa, & Mitsuya, 2000).

Little research has been devoted to analysing the chemical composition and bioactive ingredients of *Cordyceps* species, and no attention has been devoted to comparing the differences between natural DongChongXiaCao and counterfeit, mimic types and mycelium of *Cordyceps sinensis* produced by fermentation. It is important to evaluate the nutritional and health-promoting values of various sources of *Cordyceps* products as nutraceuticals. The objectives of this investigation were to characterize the proximate composition, the amino acid profiles, and the contents of the bioactive ingredients adenosine and cordycepin in the *Cordyceps* preparations, and to evaluate the nutritional and health-promoting properties of natural DongChongXiaCao, its counterfeit, the mimic, and the femented mycelium of *Cordyceps sinensis*.

2. Materials and methods

2.1. Samples

Samples of DongChongXiaCao (*Cordyceps* sp.), its counterfeit, and the mimic (*Starchys geobombycis*) were purchased from a Chinese drugstore and market in Taiwan. Individual samples of the DongChongXiaCao and its counterfeit were composed of a fruiting body connected to the corpus in a caterpillar shape. The samples were easily broken into two parts manually from the connection site for further study. The counterfeit was picked up and separated from the genuine by carefully identifying the corpora lacking abdominal legs when viewed under a stereomicroscope. The mimic was discriminated by the lack of a fruiting body connected to the caterpillar-shaped root and its corpulence in shape. Before the experiments, the materials were milled in a blender to the contituency of a powder. The mycelium of *Cordyceps sinensis* was produced by fermentation.

2.2. Mycelium of Cordyceps sinensis by fermentation

2.2.1. Microorganism

The fungal strain used (deposited at the Culture Collection & Research Centre, Food Industry Research and Development Institute, Hsinchu, Taiwan) was *Cordyceps sinensis* (CCRC 36421). The strain was maintained on potato dextrose agar (PDA) plates at 5 °C in a refrigerator and subcultured at 2-week intervals. Slant cultures of a mixture of spores and mycelia were stored at −18 °C.

2.2.2. Seed culture

Starter flasks (250 ml) of potato dextrose broth (PDB) were inoculated with mycelia mat (ca. 1 cm^2) from a stock culture and incubated on a shaker at 200 rpm for 5 days at 22 °C. The starter cultures (20 ml) were transferred to 500-ml Erlenmeyer flasks with 200 ml PDB media as seed cultures incubated on a shaker at 200 rpm for 5 days at 22 °C. Fermentation broths were tested for bacterial contamination by plating 1 ml aliquots on nutrient agar plates for 2 days at 37 °C prior to inoculation into the fermenter.

2.2.3. Fermentation

The fermentations were performed in a 5-l fermenter (Top-Bio, Taiwan) with a working volume of 3 l and 10% inoculum at 22 °C for a period of 5 days. The medium was the same as the seed culture, the pH of which was adjusted to 5.5 prior to sterilization. The initial agitation rate of 200 rpm was increased to 350 and 400 rpm after the 3- and 4-day fermentations, respectively. The culture was aerated at a rate of 1 vvm. After fermentation, the broths were examined under a microscope for mycelial formation and tested for bacterial contamination by plating on nutrient agar plates, as described earlier. The fermented mycelium was obtained in pellets from the broth after centrifugation at 15,000 ***g*** for 30 min. The mycelium and the supernatant from the broth were subjected to freeze-drying and stored at −18 °C in a freezer for further chemical analysis.

2.3. Analysis methods

2.3.1. Proximate composition

Samples were analyzed for proximate composition (protein, fat, carbohydrate, ash and moisture) according to the AOAC (1995) procedures. The percentage of protein was calculated as $N\times4.38$ (Crisan & Sands, 1978).

2.3.2. Amino acids

Amino acids were determined using an automatic amino-acid analyzer (Beckman 6300, Beckman Instruments, Fullerton, CA) according to the method described by Moore and Stein (1963) and Danell and Eaker (1992). Hydrolysis of the samples was performed in the presence of 6 M HCl containing 5 mg phenol ml^{-1} (for protection of the tyrosine) and 5 μmol of norleucine as an internal standard at 110 °C for 24 h under a nitrogen atmosphere. The hydrolysate was evaporated and the residue was redissolved in 0.5 ml of citrate buffer. The sample was filtered through a 0.45 μm filter membrane before being injected into the amino acid analyzer.

2.3.3. Adenosine and cordycepin by HPLC

Accurate amounts of adenosine and cordycepin were dissolved in a mobile phase solution, as described later, to give various concentrations for calibration. Samples were extracted by 100 °C hot water for 2 h and filtered through a 0.45 μm filter membrane prior to analysis. Analysis was performed using a HITACHI L-6200 pump with a RHEODYNE M-4250 injector, L-4250 detector and D-2500 integrator. A pre-packed RP column Cosmosil 5C18 (4.6×250 mm, 5 μm particle size) of Nacalai Tesque (Kyoto, Japan) was used. The mobile phase was a mixture of methanol/0.02 M potassium dihydrogenphosphate (15:85). Elution was performed at a solvent flow rate of 1 ml/min starting with 30% methanol, which remained isocratic for 15 min; then a gradient was installed to obtain 40% methanol at 20 min, 45% methanol at 30 min, 60% methanol at 50 min, and 80% methanol at 52 min, subsequently becoming isocratic for 60 min. Detection was performed with a variable-wavelength UV detector (L-4250) at 260 nm.

2.4. Statistical analysis

The results were expressed as the means of three separate determinations. The data were statistically analyzed according to SAS (1985). Significant differences between any two means were determined at the 5% level.

3. Results

3.1. Proximate composition of samples

Proximate compositions in the genuine DongChongXiaCao, the fermentation preparations of *Cordyceps sinensis*, the counterfeit DongChongXiaCao, and the mimic DongChongXiaCao are presented in Table 1. It was believed that the corpus and the fruiting body of DongChongXiaCao had different functions, due to the former existing underground and the latter growing above ground, for use as traditional Chinese medicine (according to common legend). There were significant differences in both ash and moisture content between the corpus and the fruiting body of the genuine fungus, but the protein, fat and carbohydrate contents did not differ statistically. The 8.64% ash content in the fruiting body was three times higher than in the corpus of the DongChongXiaCao.

Significant differences were observed between the genuine (both the corpus and the fruiting body) and the fermented mycelium of *Cordyceps sinensis* in respect to protein, fat, carbohydrate and moisture contents. The conspicuously high carbohydrate content (39.4%) comprised the main part of the fermented mycelium compared with 24.20% in the corpus and 24.9% in the fruiting body of the genuine fungus, respectively. The fermented mycelium had lower protein and fat contents (14.8 and 6.63%, respectively) than did the corpus (29.1 and 8.62%) or the fruiting body (30.4 and 9.09%) of genuine fungus. The freeze-dried supernatant of the fermentation broth from *Cordyceps sinensis* contained much carbohydrate (24.5%), but the protein, fat and ash contents were less than 2.06%.

There were statistically significant differences in the protein, fat, carbohydrate and ash contents among the genuine, the counterfeit and the fermented mycelium; however, no differences were found between the corpus and the fruiting body of the counterfeit fungus. The counterfeit is a carbohydrate-rich (47.0–47.8%) material, having a relatively low fat composition (0.57–0.60%), its

Table 1
Proximate composition of genuine DongChongXiaCao, fermented preparations of *Cordyceps sinensis*, counterfeit DongChongXiaCao and mimic DongChongXiaCao (*Stachys geobombycis*)[a]

	Genuine DongChongXiaCao		Fermented preparations of *C. sinensis*		Counterfeit DongChongXiaCao		Mimic DongChongXiaCao
Chemical composition (%)	Corpus	Fruiting body	Mycelium	Supernatant of broth	Corpus	Fruiting body	*Starchys geobombycis*
Protein	29.1a	30.4a	14.8b	2.05c	11.00d	9.57d	7.99e
Fat	8.62a	9.09a	6.63b	1.23c	0.57d	0.60d	0.62d
Carbohydrate	24.2a	24.9a	39.4b	24.5a	47.8d	47.0d	45.9d
Ash	2.85a	8.64b	2.95a	1.62a	5.53c	5.51c	3.38d
Moisture	8.93a	10.87b	6.40c	12.07d	12.24d	20.02e	12.70d

[a] Means with different letters in the same row are significantly different ($P < 0.05$).

Table 2
Amino acid levels in genuine DongChongXiaCao, fermented preparations of *Cordyceps sinensis*, counterfeit DongChongXiaCao and mimic DongChongXiaCao (*Stachys geobombycis*)[a]

	Genuine DongChongXiaCao		Fermented preparations of *Cordyceps sinensis*		Counterfeit DongChongXiaCao		Mimic DongChongXiaCao
Amino acid composition (%)	Corpus	Fruiting body	Mycelium	Supernatant of broth	Corpus	Fruiting body	*Starchys geobombycis*
Aspartic acid	1.70a	1.84a	1.05ab	0.31c	0.62bc	0.82ab	0.51bc
Threonine	0.86a	0.83a	0.65a	0.05c	0.21bc	0.35b	0.27b
Serine	0.77a	0.78a	0.49b	0.04c	0.31bc	0.77a	0.23bc
Glutamic acid	2.64a	2.66a	1.12a	0.48b	0.54b	1.55ab	0.61b
Proline	1.13a	0.95a	0.72a	–	–	–	–
Glycine	0.82a	0.73ab	0.58ab	0.09c	0.21c	0.38bc	0.18c
Alanine	1.02a	0.95a	0.75a	0.05b	0.21ab	0.45ab	0.18ab
Valine	0.98a	0.80a	0.63b	0.06c	0.17c	0.48b	0.25bc
Methionine	0.26a	0.18a	0.18a	0.02b	–	0.17a	–
Isoleucine	0.81a	0.53b	0.44ab	0.05c	0.25bc	0.41b	0.22bc
Leucine	1.30a	0.95a	0.69ab	0.06d	0.32c	0.70ab	0.28c
Tyrosine	0.89a	0.67ab	0.31b	0.02c	–	0.22b	–
Phenylalanine	0.96a	0.61b	0.50bc	0.04d	0.36c	0.52bc	0.28c
Histidine	1.07a	1.13a	0.28ab	0.02c	0.74a	0.17b	0.89a
Lysine	1.38a	1.15a	0.80a	0.08b	0.19b	–	0.22b
Arginine	1.53a	1.60a	0.04ab	0.05b	–	–	–
Total	18.1a	16.4a	9.23b	1.42d	4.13cd	6.99bc	4.12c

[a] Means with different letters in the same row are significantly different ($P < 0.05$).

protein content (9.57–11.0%) also being less than that of genuine or fermented mycelium. A markedly higher moisture content (20.02%) of the counterfeit was present in the fruiting-body portion compared with that in the genuine or fermented mycelium. Significant discrepancies were exhibited in the proximate composition of the mimic compared with the genuine fungus. A comparison between the mimic and the counterfeit showed that the protein and ash contents were significantly different.

3.2. Amino-acid composition of samples

Amino acid compositions in the genuine DongChongXiaCao, the fermentation preparations of *Cordyceps sinensis*, the counterfeit DongChongXiaCao, and the mimic DongChongXiaCao are presented in Table 2. There were no statistically significant differences in the total and individual levels of amino acids, except for isoleucine and phenylalanine, between the corpus and the fruiting body in the genuine fungus. The three principal amino acids and their levels in the corpus-fruiting body are 2.64–2.66% glutamic acid, 1.70–1.84% aspartic acid and 1.53–1.60% arginine. Apparently, the lower total level of amino acids is 9.23% in the fermented mycelium compared with 18.1% in the genuine fungus.

The three principal amino acids and their levels in the fermented mycelium are 1.12% glutamic acid, 1.05% aspartic acid and 0.80% lysine. Statistically significant differences existed in the levels of four amino acids, namely serine, valine, tyrosine and phenylalanine, between the fermented mycelium and the corpus of the genuine fungus. Only two amino acids, serine and valine, showed statistically different levels between the fermented mycelium and the fruiting body of the genuine fungus.

The levels of amino acids in the fermented mycelium are similar to those in the fruiting body of the genuine fungus, although the total levels of amino acids were different. There were no statistically significant differences in the total levels of amino acids between the corpus and the fruiting body of the counterfeit (4.13 and 6.99%, respectively). These values were lower than those in the genuine and the fermented mycelium. There were discrepancies in the levels of amino acids in the counterfeit, as expected, compared with those in the *Cordyceps* preparations.

The three principal amino acids and their levels in the corpus and the fruiting fungus body of the counterfeit fungus were 0.74% histidine, 0.62% aspartic acid and 0.80% glutamic acid, and 1.55% glutamic acid, 0.82% aspartic acid and 0.82% serine, respectively. The mimic had a total amino-acid level of 4.12%; the three principal amino acids and their respective levels were 0.89% histidine, 0.61% glutamic acid and 0.51% aspartic acid. Glutamic acid and aspartic acid were also major constituents of the amino acids in the genuine and the fermented mycelium.

Table 3
Amounts of adenosine and cordycepin in genuine DongChongXiaCao, fermented preparations of *Cordyceps sinensis*, counterfeit DongChongXiaCao and mimic DongChongXiaCao[a]

	Genuine DongChongXiaCao (*Cordyceps* sp.)		Fermented preparations of *C. sinensis*		Counterfeit DongChongXiaCao (*Cordyceps* sp.)		Mimic DongChongXiaCao
Bioactive ingredient (μg/g)	Corpus	Fruiting body	Mycelium	Supernatant of broth	Corpus	Fruiting body	*Starchys geobombycis*
Adenosine	311b	1930a	2.0c	2.7c	–	–	–
Cordycepin	5.4a	2.4b	1.4b	1.9b	–	–	–

[a] Means with different letters in the same row are significantly different ($P < 0.05$).
Symbol "–" means not detected.

3.3. Adenosine and cordycepin concentrations in samples

Adenosine and cordycepin concentrations in the genuine DongChongXiaCao, the fermentation preparations from *Cordyceps sinensis*, the counterfeit DongChongXiaCao and the mimic DongChongXiaCao are presented in Table 3. The adenosine concentration, consisting of 1930 μg/g in the fruiting body, was approximately six-fold higher than in the corpus; however, the cordycepin concentrations of 2.4 and 5.4 μg/g in the former and the latter, respectively, are relatively low for the genuine fungus. Adenosine and cordycepin, in inconsequential amounts, occurred in the mycelium and the supernatant from the broth via fermentation but were not detected in the counterfeit and the mimic types.

4. Discussion

The use of DongChongXiaCao (*Cordyceps* sp.) as a medicine and tonic food has been appreciated for thousands of years in China. Recently, extracts of DongChongXiaCao and fermented mycelium of *Cordyceps sinensis* have been promoted as health foods, functional foods or nutraceuticals. It is also an edible mushroom, typically cooked with chicken or duck soup, as a medicinal repast, for restoring health. The nutritional value of DongChongXiaCao as an edible mushroom has been disregarded due to extensive medical claims. Furthermore, both natural DongChongXiaCao and fermented mycelium of *Cordyceps sinensis*, as health foods, are unattractive to consumers with regard to quality and price.

Little scientific information is available to differentiate these *Cordyceps* preparations by proximate composition and bioactive ingredients. Genuine DongChongXiaCao contains about 30% protein, 9% fat, 25% carbohydrate, 6% ash, and 10% moisture. Compared with most of the mushrooms described by Crisan and Sands (1978), both the carbohydrate and the ash contents are low and the fat content high. Great variation in chemical composition occurs within or between species of edible mushrooms, the protein content ranging from 8.9 to 33.8%, and the ash content ranging from 2.1 to 16.6% for the tropical species (Aletor, 1995). Even within the same species or variety, the proximate composition is affected by the cultivation substrate with respect to carbon and nitrogen sources and their ratios (Yildiz, Karakaplan, & Aydin, 1998).

Natural DongChongXiaCao originates from *Cordyceps* sp. using the larva of *Hepialus armoricanus* as the growth substrate. It might differ in chemical composition from the fermented mycelium of *Cordyceps sinensis* when using PDB as the medium. This has been confirmed by our studies. This finding disagrees with a report by Cheung (1997) that the contents of crude protein, lipid and ash vary within only a narrow range between the fruiting bodies and the mycelia of the edible mushrooms *Volvariella bombycina*, *Lyophyllum ulmarius* and *Pleurotus citrinopileatus*. The carbohydrate content is higher than the protein content of the fermented mycelia of *Cordyceps sinensis*, which is contrary to the natural DongChongXiaCao. In the same species of the edible mushroom *Agrocybe cylindracea*, a carbohydrate content higher than the protein content of strain M, contrary to strain B, has been described (Mau & Tseng, 1998).

A high carbohydrate content of edible ear mushrooms has been reported, ranging from 68.9 to 88.1% (Mau, Wu, Wu, & Lin, 1998). Recently, much interest has arisen in characterizing relationships between the structure and function of water-soluble and water-insoluble polysaccharides obtained from fruiting bodies, mycelium and fermentation broth of mushrooms because of their antioxidant, free radical scavenging, antiviral, hepatoprotective, antifibrotic, anti-inflammatory, antidiabetic and hypocholesterolemic activities (Ooi & Liu, 1999). The fermented mycelium of *Cordyceps sinensis* contains less fat, 6.63%, than that of the natural DongChongXiaCao corpus (8.62%). The mycelium of the Nigerian edible mushroom *Volvariella esculenta,*

cultivated on agricultural wastes, contains only 3% fat (Fasidi, 1996).

The counterfeit DongChongXiaCao contains about 10% protein, 0.6% fat, 47% carbohydrate, 6% ash and 16% moisture. It is presumed to be of a plant origin and different from the mimic DongChongXiaCao, a root of *Stachys geobombycis*, silkworm *Bombyx mori*-like, by morphological identification (Be & Ma, 1995; Chen, Gee, Lee, & Yueh, 1991). *Stachys* is also called Labiatae, a mint family of flowering plants, with about 160 genera and 3500 species, the largest family of the order Lamiales. These herbs are important to humans for their flavour, fragrance, or medicinal properties. The anti-inflammatory, antitoxic, and hypoazotemic activities of *Stachys* spp. have been studied (Maleki et al., 2001; Zinchenko, Voitenko, & Lipkan, 1981).

For enhancing the phagocytic activity of monocytes in mice for the immunological properties of amino acids from natural DongChongXiaCao have been studied (Zhang, Zhang, Zhu, & Chen, 1991). The level of total amino acids in the natural DongChongXiaCao was about 17% in our finding, less than the result of 23% from the investigation by Zhang et al. (1991), the data of which show two of the three principal amino acids, glutamic acid and arginine, in accordance with our study; however, the third is tryptophan instead of aspartic acid.

The three most abundant amino acids, namely, glutamic acid, aspartic acid and arginine for the interspecies of edible mushrooms *Pleurotus* spp. and *Cantharellus cibarius*, have also been noted (Danell & Eaker, 1992; Manzi, Ganbelli, Mstvoni, & Vivanti, 1999). However, glycine, glutamate and alanine are the most plentiful amino acids in all the tested wild edible mushrooms *Termitomycetes robustus*, *Tricholoma lobayensis* and *Volvariella esculentia* (Alofe, 1991). Variations in the amino acid content between the corpus and the fruiting body of natural DongChongXiaCao, as well as in the fermented mycelium of *Cordyceps sinensis* were shown in our study. It has been observed that the varying levels of amino acids are related to the different parts, stage of development and type of mushroom (Alofe, 1991).

The adenosine amount of 1930 μg/g in the fruiting body of natural DongChongXiaCao approaches the 2470 μg/g of those of the natural DongChongXiaCao from a different source determined by Shiao, Wang, Lin, Lien, and Wang (1994). Cordycepin originates from the supernatant of fermentation broth *Cordyceps militaris*, first reported by Cunningham, Manson, Spring, and Hutchinson (1950). Trace amounts of cordycepin were detected in all the *Cordyceps* preparations, although cordycepin was not detectable in several *Cordyceps* species, including *Cordyceps sinensis*, *Cordyceps militaris* and others described by Shiao et al. (1994). Trace amounts of cordycepin, 67 μg/g, have also been detected in fermented mycelium of *Cordyceps sinensis* (Shei, Kwou, Lee, & Hsu, 1994).

5. Conclusion

A compositional analysis for judging the nutritional quality and bioactivity of medicinal edible mushrooms is important, whether they are used for ordinary foods, health foods, functional foods or nutraceuticals. The crude drug DongChongXiaCao, as sold in Chinese drugstores arises from a natural environment other than cultivation under control. The milled powders or extracts from these materials have been used in everything from crude drugs to health foods. Usage and dosage for medicinal purposes are pronouncedly different from that as foods. The relationships and mechanisms between bioactivity and bioactive ingredients remain unclear.

Chemical constituents of natural crude drugs, including DongChongXiaCao occurring in nature, are affected by location, geography, climate and microenvironment. The advantages of stability in quality and inexpensive cost in contrast with that of natural DongChongXiaCao have been established for the fermented mycelium of *Cordyceps sinensis*. Attention has been given to the counterfeit and the mimic DongChongXiaCao since they have been used as food material in restaurants, especially for medicinal refection. Our findings have clarified the differences with regard to the proximate composition, amino acid profiles and the bioactive ingredients among the genuine, the counterfeit, the mimic DongChongXiaCao and the fermented mycelium of *Cordyceps sinensis*, and demonstrated their nutritional properties.

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